Northeast Fisheries Science Center Reference Document 06-12

Report from the Atlantic Surfclam (*Spisula solidissima*) Aging Workshop Northeast Fisheries Science Center, Woods Hole, MA, 7-9 November 2005

by Larry Jacobson, Sandra Sutherland, Jay Burnett, Maureen Davidson, Juliana Harding, Jeff Normant, Adriana Picariello, and Eric Powell

July 2006

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SECTION 1. INTRODUCTION

A workshop was held at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts during November 7-9, 2005, to facilitate communication among scientists involved in aging Atlantic surfclam (*Spisula solidissima*) and to lay the groundwork for future collaboration. The workshop included (a) scientists from the NEFSC, the New York State Department of Environmental Conservation (NYSDEC), the Virginia Institute of Marine Science (VIMS), and Rutgers University, and (b) industry representatives.

This workshop was important and timely because age data from state and federal surfclam surveys are expected to be used more extensively in future surfclam stock assessments. Age data are important in fishery stock assessment analyses for surfclam and other species because age data contain information about growth, recruitment, and mortality. The fishing industry is interested in age data because information about the geographic location and timing of recruitment events is important in making business plans and managing the stock.

The objectives of the workshop were to:

1. describe sampling, processing, aging, and QA/QC protocols/methods for surfclam aging programs at each laboratory;
2. discuss aging terminology, birthdate conventions, and annulus identification; and
3. develop the framework for periodic aging exchanges between aging programs and the establishment of a surfclam reference collection.

A significant portion of the workshop was spent with the three professional age readers and other participants gathered around a TV screen that displayed images of magnified specimens. This arrangement allowed all participants to view samples from various areas, to gain experience with aging procedures, and to discuss how closely they agreed on age determinations for each specimen.

Although a number of issues and uncertainties were discussed during the workshop, experienced age readers at the meeting indicated that Atlantic surfclam are easier to age than many fish species that are aged on a routine basis. Informal analysis of age composition data from the NEFSC clam surveys in the most recent stock assessment (NEFSC 2003) indicates that the age data for Atlantic surfclam are likely to be useful in stock assessment work. In particular, two strong cohorts were evident in survey age data for the New Jersey and Delmarva regions (Figure 1). The mode in survey age data at 5 y during 1997 shows up again as a mode at 6-7 y during 1999 and as a mode at 9-11 y in 2002. A relatively strong cohort at 3-4 y is evident in both areas during 2002.

This section of the report describes the dates, venue, and objectives of the workshop. Section 2 gives relevant biological information and describes past aging studies, current programs and ongoing research. Section 3 lays out general issues involved in processing and aging surfclam. Section 4 provides recommendations for future work. Appendix 1 is the workshop agenda. Participants (with a group photo) are listed in Appendix 2.

SECTION 2. SURFCLAM BIOLOGY

Biological characteristics are important because they affect timing and development of annual marks used to age Atlantic surfclam. Biological information about Atlantic surfclam in the rest of this report is from Cargnelli et al. (1999) or Ropes and Shepherd (1988), unless otherwise noted. The former is a thorough review of biological and habitat characteristics. The latter emphasizes aging techniques for Atlantic surfclam.

In United States waters, major concentrations of Atlantic surfclam are found on Georges Bank, south of Cape Cod, and off Long Island, southern New Jersey, and the Delmarva Peninsula (Cargnelli et al. 1999). Atlantic surfclam inhabit waters from the surf zone to a depth of 128 m but are found most often at depths of less than 73 m in well-sorted, medium sand in turbulent areas beyond the breaker zone. Along Long Island and New Jersey, the highest concentrations occur in waters shallower than 18 m. In contrast, off the Delmarva Peninsula, the greatest concentrations occur from 18 to 36 m. Atlantic surfclam are typically found in areas where bottom temperatures rarely exceed 25°C and where salinities are higher than 28 ppt.

Surfclam have separate sexes, although some individuals are hermaphroditic (Cargnelli et al. 1999). In the Middle Atlantic Bight, spawning occurs primarily during summer, although some activity has also been documented in autumn. Full sexual maturity is attained in the second year of life at a shell length of 45 to 85 mm.

Atlantic surfclam spawn in the summer and early fall at temperatures above 15°C. In New Jersey, spawning occurs from late June to early August, although spawning may begin as early as late May or early June closer inshore (Cargnelli et al. 1999). Spawning begins and ends earlier in the south. In Virginia, for example, it may begin in May and end in July. There may be a second, minor spawning in October, caused by breakdown of the thermocline. In cold years, the second spawning may not occur.

A southern subspecies, *S. solidissima similis,* occurs primarily south of Cape Hatteras (Cargnelli et al. 1999). Based on unconfirmed but probably reliable reports, *S. solidissima similis* has become more common during recent years in northern coastal areas such as Long Island Sound (M. Davidson, New York State Department of Environmental Conservation, pers. comm.). *S. solidissima similis* is shorter-lived, grows to a smaller maximum size, and spawns in the spring to early summer. The two subspecies can be distinguished based on shell morphology and habitat but may be confused occasionally in samples from warm coastal areas. Distinguishing between the two species may become more important in the future because coastal waters will probably continue to warm (Nixon et al. 2004) and the distribution of *S. solidissima similis* is likely to shift northward. Under warm water conditions, *S. solidissima similis* is more likely to be found in areas originally occupied by Atlantic surfclam (Weinberg 2005).

Growth of Atlantic surfclam is fairly rapid to about age 7 (Figure 2), but diminishes thereafter (Cargnelli et al. 1999). Maximum shell length is about 23 cm (9 in) and longevity may be as high as 37 years. Growth of Atlantic surfclam varies by region (Weinberg and Helser 1996) and may be slower in regions where density is highest (Weinberg 1998).

Growth is not uniform throughout the year (Cargnelli et al. 1999). Growth of Atlantic surfclam in the Middle Atlantic Bight was positively correlated with temperature and negatively correlated with variation in temperature. For example, growth in the coastal Gulf of Maine was higher at warmer temperatures and at higher chlorophyll concentrations. Shell growth in New Jersey waters reflects seawater temperature; growth is most rapid in spring and early summer, slow in late-summer and fall, and extremely slow or non-existent in winter.

Previous age reading methodology studies

Annual marks ("annuli") that are counted and used to age surfclam are clearly visible in surfclam shells and shell sections (Ropes and Shepherd 1988). Annual growth comprises alternating bands of relatively broad opaque (more calcified) zones formed during periods of fast growth and relatively narrow translucent (less calcified or "hyaline" zones formed during periods of slow growth. These hyaline zones are considered to be annuli.

Using transmitted light, annuli appear light, owing to the passage of light through the less-calcified shell material. Under reflected light, annuli appear dark for the same reason. Surfclam are usually aged under reflected light, as this approach requires less time and expense for sample preparation.

Environmental conditions may influence the timing of annulus formation. Surfclam from inshore and offshore regions along the Middle Atlantic coast grow at different rates and consequently have different annuli patterns. In some dynamic environments, conditions are not suitable for consistent deposition of annular material.

In 1975, procedures were developed for sectioning whole valves from the umbo to valve margin using a diamond-impregnated saw blade (Ropes and Shepherd 1988). The cut edges were then polished to remove saw marks and enhance the growth structures. Distinctive dark lines seen in the cut edges of the valves terminated at external rings on the surface of the shell. The annual periodicity of these lines was validated by marking experiments (Ropes and Merrill 1976, Jones et al. 1978). Although the method was reliable, age determinations required careful microscopic examination of the cut surface, which, together with the cutting and polishing procedures, proved to be excessively time-consuming.

The method used currently (described below) is more efficient and based on annuli in the chondrophore (Ropes and Shepherd 1988). According to reports (no longer available) cited by Ropes and Shepherd (1988), the number of annual marks in valves corresponded with the number of annual marks in chondrophore sections. Ropes and O'Brien (1979) report a 97% linear correlation between valve length and chondrophore length. These results suggest that chondrophores may work as well as shell sections in aging Atlantic surfclam. It is important to note, however, that age estimates from chondrophores have not been validated directly.

Geographic differences in the timing of annulus formation create confusion in age interpretation (Ropes and Shepherd 1988). Ages are usually assigned assuming 1 January as the birthdate. Annuli formed in early fall may show substantial growth that occurred prior to the assumed 1

January birthdate. Therefore, caution must be exercised in assigning an additional year of age due to a specimen with a hyaline zone at the distal edge of samples collected between the time of annulus formation and the beginning of January. Two studies found developing annual marks during late summer-early fall for specimens collected off New Jersey with annulus formation later in the fall (October-November) for surfclam off Delmarva (Ropes and Shepherd 1988).

The first annulus is usually a single, relatively narrow hyaline zone (Ropes and Shepherd 1988). Distance from the umbo to the distal edge of the first hyaline zone is variable. Typically, this variation results from an annual variation in the timing of larval production and settlement due to protracted spawning activity, or to differences in growing conditions at the place of settlement.

The second to tenth annuli appear relatively clear in Atlantic surfclam (Ropes and Shepherd 1988). Double hyaline zones with a split annulus are separated from preceding and subsequent annuli by wide opaque bands. Widths of annuli are compressed as surfclam age and growth slows. Hyaline zones and opaque bands of subsequent annuli are somewhat compressed.

Existing programs and current research

Age data are collected on a routine basis from samples taken on research surveys carried out by the New York State Department of Environmental Conservation (NYSDEC) and by the NEFSC. The New Jersey Department of Fish and Wildlife (NJDFW) also conducts clam surveys but samples are not collected for aging. The Virginia Institute of Marine Science (VIMS) and the Haskin Shellfish Laboratory at Rutgers University conduct research on surfclam aging. All of the existing programs and research are accomplished in close collaboration with the fishing industry, which provides financial support and makes extensive use of the resulting information. Each of the existing programs and current research projects are described below.

With the exception of a single aspect (when a hyaline zone is found at the edge of a chondrophore, see *Issues* and *Recommendation* sections), participants at the workshop concluded that differences in procedures used by VIMS, NYSDEC and NEFSC to section and age surfclam were superficial. Participants hypothesized that similar age estimates would be obtained using either method.

New York State Department of Environmental Conservation

Surfclam surveys were carried out by the NYSDEC (Davidson et al. 2005) aboard commercial fishing vessels during August-September of 1993, 1994, 1996, 1999, 2002 and 2005. NY state waters (less than 3 nautical miles from shore) were surveyed along the south shore of Long Island between Rockaway Inlet and Montauk Point (Figure 3). Aging of these samples commenced in 2002. The sampling and aging procedures described below were used to determine ages of surfclam collected during the 1999 – 2005 NYSDEC surveys (Davidson et al. 2005). Age reader training is provided to seasonal staff by the biologist in charge (M. Davidson), who was trained by R. Cerrato at the Marine Sciences Research Center, SUNY, Stony Brook.

NYSDEC surfclam surveys since 1992 were carried out on the *F/V Ocean Girl*, an 80-foot stern-rigged commercial surfclam fishing vessel, equipped with a hydraulic clam dredge (90-in blade) operated at approximately 80 psi. The dredge was lined with 1.5 inch square wire mesh to insure that small surfclam were retained during survey operations.

At each survey station, five randomly selected surfclam were measured (shell length to the nearest millimeter) and shucked. The right valve was retained in a labeled bag for aging. In the laboratory, the shells were washed, dried and labeled with the station and shell numbers. After labeling, the shells were trimmed, leaving the chondrophore and sufficient shell for further processing. Each trimmed shell was placed in a labeled plastic bag. All shells from the same station were kept together in a larger labeled bag. About 1,200 clams are aged per survey.

A Buehler Isomet 1000 precision saw was used to cut shells for aging. The load on the saw was approximately 80 g and the blade speed was 600 rpm. Blade speed was decreased further to avoid breaking very small or thin shells. Prior to cutting, pencil marks were made at the center of the bottom edge of the chondrophore and at the center of the umbo (Figure 4). These pencil marks were aligned with the saw blade and used to help place the trimmed shell on the saw chuck and guide the direction of cutting. The cutting process was monitored carefully to ensure that the cut was in the correct position (Figure 5). If the alignment was wrong, the saw was stopped and the shell was repositioned on the chuck of the saw. Shells were cut once through the center of the chondrophore. Once cut, both halves of the shell were labeled and kept in the same sandwich bag. The shell was discarded if an appropriate cut could not be made.

Cut shell halves were held in sand while an image of the chondrophore was projected onto a TV screen for viewing (Figure 6). Light and dark rings are readily visible in the cross-section of the cut chondrophore. The dark rings were assumed to be annual marks and counted to determine the age of the shell. One year was added to the age if the edge of the chondrophore was hyaline. Each shell was aged individually by two persons. If the ages differed, a third person aged the shell, and the best estimate of age was determined by discussion. If agreement on the age could not be reached, the shell was discarded. Maximum age in NYSDEC samples has been about 26 y for samples outside of Long Island Sound, and about 11 y for samples from within Long Island Sound.

Surfclam age and survey data collected by NYSDEC are stored in Excel files. The data from this survey are an important source of information about year-class strength and stock size in NY state waters.

Northeast Fisheries Science Center

Northeast Fisheries Science Center clam surveys in federal waters were conducted during May-July approximately every three years since 1982. The survey is carried out in continental shelf waters between Georges Bank on the US-Canada border and Southern Virginia/North Carolina, at depths of 10-200 m (Figure 7). The NEFSC survey also targets ocean quahogs (*Arctica islandica*), which occur on the continental shelf in deeper waters than Atlantic surfclam.

The NEFSC clam surveys are conducted by the *R/V Delaware II* using a hydraulic dredge that differs from commercial dredges in having a submersible pump mounted on the dredge. The NEFSC clam survey dredge has a 60-inch blade, a 2-inch mesh liner in the cage to retain small clams, and is operated at about 40 psi. Station locations are randomly selected except for special studies.

Surfclam taken in the survey (one clam from each 10-mm size group at each station) are aged routinely following each survey. Roughly 1000 clam shells have been aged per survey during recent years.

Each sample saved for aging is measured again at the lab to verify length, width, and height of shells. The more complete shell (right or left) is chosen for further processing, and trimmed to fit into the saw. Chondrophore sections are cut along a line from the umbo to the valve margin (Figure 8) using a Buehler Isomet low-speed saw mounted with two diamond-impregnated blades (Figure 9).

Age is determined by counting the dark rings (assumed to be annual marks; Figure 10) on the cut sides of the chondrophore section (Ropes and O'Brien 1977). Rings are counted under reflected light using a dissecting microscope at 50-100x magnification. Each sample is aged twice, and if the two ages disagree, the sample is viewed once again to establish a consensus age before inclusion in the database. Aging and processing methods are modified from Ropes and Shepherd (1998).

Age data for surfclam taken in NEFSC surveys are ring counts *per se*. When the age data are recorded, no adjustment is made to the number of rings counted to account for the age reader's beliefs about visibility of the first annulus, timing of annulus formation, date of sampling or other factors that complicate age assignment for surfclam (see below). This policy is advantageous because the data stored in the database are not affected by assumptions that may prove incorrect. If future research shows that adjustments are required, then the adjustments can be made after the data are extracted based, for example, on location and date of capture, latitude and other variables.

Formal experiments to measure age reader precision are now conducted as part of standard aging procedures. This allows one measurement of 'aging error' which can then be reported in stock assessments, or even incorporated into population models. In addition, an aging warm-up, using samples from a previous year, is conducted prior to aging any new samples.

Data from NEFSC clam surveys are stored in an Oracle database, which also includes information about where and when the specimen was collected, shell dimensions, weight, and age. Meat weight data are collected from a subsample of the clams aged from some surveys. For surveys since 2001, it is possible to link shells with specimen-specific data such as meat weights.

New Jersey Department of Fish and Wildlife

Surfclam surveys were carried out in New Jersey state waters on a generally annual basis during 1988-2004 by NJDFW Bureau of Shellfisheries (Normant 2005) using commercial fishing vessels. However, surfclam samples for aging were not collected.

Surveys during 2000-2004 included extensive Peterson grab samples that captured many small (1-46 mm) juvenile surfclam. These juvenile surfclam taken in grab samples may be very useful in detecting new recruitment, in estimating the growth rate of young animals, and in identifying the position of the first annulus.

Virginia Institute of Marine Science and Rutgers

Three studies by academic collaborators at VIMS and Rutgers are significant in the context of aging Atlantic surfclam. The first study relates latitudinal and bathymetric patterns in growth to environmental conditions and, in particular, to recent coastal warming that has shifted the geographic distribution of Atlantic surfclam northward and into deeper water. Collections include surfclam 32-180 mm shell length from southern, northern, inshore and offshore areas along the coast. Ages are determined using methods used at the NEFSC. Growth curves for clams from different areas will be developed and compared statistically. It is likely that this project may also be useful in validating chondrophores used in aging Atlantic surfclam.

The goal of the second study is to develop predictive relationships between the location of annual marks in the chondrophore and shell length in Atlantic surfclam. This type of predictive relationship can be used to "back-calculate" growth curves for individual surfclam from annuli in chondrophores. Similar approaches are widely used to back-calculate growth of individual finfish based on the position of annual marks in scales and otoliths (Le Cren 1947, Casselman 1983). The principal impediment to back-calculating growth curves for Atlantic surfclam is uncertainty about the exact relationship between annual marks in the chondrophore and shell length.

The third study involves using new optical and digital technologies that can be used to characterize molluscan growth patterns at annual and sub-annual time intervals. The main goal is to interpret sub-annual growth patterns in relation to environmental conditions and the annual spawning cycle. These methods are currently not suited for routine aging because large amounts of data are generated from relatively small numbers of individuals. However, the technology does show promise as an alternate and objective means to estimate age in difficult or unusual specimens, and as a means to provide quality control in routine aging work. In this context, the new optical and digital methods are promising because age estimates are objective and repeatable once parameters used to interpret the data are specified.

SECTION 3. PROCESSING/AGING ISSUES

Key issues and problems identified at the workshop are described below. The list is organized in approximate priority order.

1) There is uncertainty about the position and nature of the first annulus in surfclam. This is an important consideration because identification of the first annulus affects all age data for surfclam.

2) Several studies support the use of chondrophores for aging surfclam but this approach has not yet been validated.

3) No birthdate has been established for aging surfclam, as all samples have been taken on surveys during the same season. The season during which annuli form is not known. The group discussed factors which may be related to growth and physiology of ring formation, including temperature, spawning season, depth, seasonality, water temperature and feeding behavior. These factors may vary latitudinally, as well, making it possible for clams in some areas to form two marks in one year or none at all. Due to the lack of knowledge about what causes these marks to form, it is not possible to agree on a single birthdate until further research has been conducted.

4) The cause and timing of band formation in surfclam is not known. Spawning may trigger the formation of hyaline zones. In hard clams, non-optimal temperatures may cause growth bands to form, as both high and low temperatures cause suspension of feeding activity and efficient respiration. It would be advantageous to investigate the causes of ring formation, particularly at the most northern and southern extent of the species range where environmental conditions are presumably suboptimal.

5) One potentially important difference exists between procedures used to age surfclam. Ring counts are recorded at the NEFSC without adjustment whereas the NYSDEC records the ring count plus one if the edge of the chondrophore is in a hyaline zone. The importance of this difference in procedure should be investigated to more accurately characterize potential differences in age data due to this procedural difference.

6) Growth curves, as estimated from surfclam age data, are likely to change over time, depth, and latitude. Growth rates increased off Delmarva, for example, after the die-off caused a hypoxia event in 1976 and growth slowed later as densities became very high (Weinberg 1998). In recent years, coastal waters have warmed (Nixon et al. 2004), and the southern boundary of the surfclam stock appears to have shifted northward (Weinberg 2005). These considerations seem to indicate that growth equations should be updated with new data at regular intervals.

7) Routine QA/QC testing to measure aging error is necessary to ensure use of consistent protocols and criteria in collecting age data for surfclam. Some of these measures are already in place at the NEFSC. These measures will likely become more important as

surfclam age data are used in stock assessment models that incorporate variance in age data.

8) Establishing a reference collection would be very useful, both to increase the accuracy of age readings and as a tool to train new age readers. The Fishery Biology Program at the NEFSC (responsible for aging a variety of fish and shellfish species) has recently been assembling a series of reference collections for other species.

9) Image analysis is a promising approach that may allow automation of aging for various species. Promising work is currently underway at VIMS to use image analysis to age ocean quahogs. This research program may soon be expanded to include surfclam aging.

10) Age data are not available for commercial fishery catches from either state or federal waters. Age data are available only from annual or triennial research surveys. This limits use of survey age data (*e.g.* age-length keys) to calculate the age composition of commercial landings because the fishery operates year-round while surveys occur mostly during May-June. In particular, commercial fishery age composition data derived from survey age-length keys may be inaccurate for relatively fast growing young surfclam caught early and late in the year. Additional sampling and age data collection from the commercial fishery may become necessary to accommodate future stock assessment work.

SECTION 4. WORKSHOP RECOMMENDATIONS

The research recommended in this section (particularly research involving the first annulus and timing of annulus formation) should be addressed prior to the 2008 NEFSC clam survey, so that high quality age data are ready for the 2009 stock assessment cycle. It is hoped that the assessment model to be used during 2009 will incorporate age data from all geographic areas along the coast. In the meantime, stock assessment work during 2006 will focus on development and testing of stock assessment models that fully utilize age data for Atlantic surfclam.

1) Studies to determine the timing of annual mark formation are a top research priority. The group agreed to put together a cooperative research plan that would, ideally, include monthly sampling at a number of ports along the coast and at a range of depths. Sample collection for this project would require industry cooperation, as many of the required samples could be obtained opportunistically during normal fishery operations. This study should elucidate what birthdate convention should be used for surfclam, or at least help to create an aging algorithm, which would convert the number of marks into an age. If the timing of annual mark formation differs along the coast, then region-specific criteria for determining age may be required.

2) New optical and digital approaches for aging Atlantic surfclam appear promising and should be pursued.

3) Henceforth, edge type should be characterized (opaque or hyaline, and relative width of the edge) and recorded for all surfclam shells that are aged. This information, along with information about the time of annulus formation, could be used to obtain better age data. This recommendation has already been incorporated into the standard NEFSC surfclam datasheet for use in the future.

4) In addition to edge type, it would be useful to record some measure of the quality of each specimen, and the level of difficulty in determining its age.

5) Conduct routine inter-calibration studies based on periodic exchanges of chondrophores between laboratories (NEFSC, NYSDEP, VIMS and others) to insure consistency of aging criteria and consistency of age data for surfclam. Exchanges should be initiated as soon as possible and will facilitate establishment of reference collections (see below).

6) A surfclam reference collection should be established, consisting of at least 300 shells. Reference collections ideally contain samples of known age. However, this does not appear possible in the near future, so a collection of shells for which consensus ages have been established will suffice. The NEFSC volunteered to host the collection, but it was emphasized that the collection would be a group product established and available to all users. It is not possible for the NEFSC to provide all samples because NEFSC surveys do not visit shallow nearshore areas. Sampling should include a range of depths, all four seasons, and both sexes. Chondrophores and digital images should be included in the reference collection.

ACKNOWLEDGMENTS

Workshop participants enjoyed and appreciated a social hosted by the surfclam fishing industry as well as support for travel and research provided by their employers. F. Serchuk and F. Almeida (NEFSC) provided helpful editorial suggestions.

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[1] Also available at: http://www.nefsc.noaa.gov/nefsc/publications/tm/tm142/tm142.pdf
[2] Available also at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0316/
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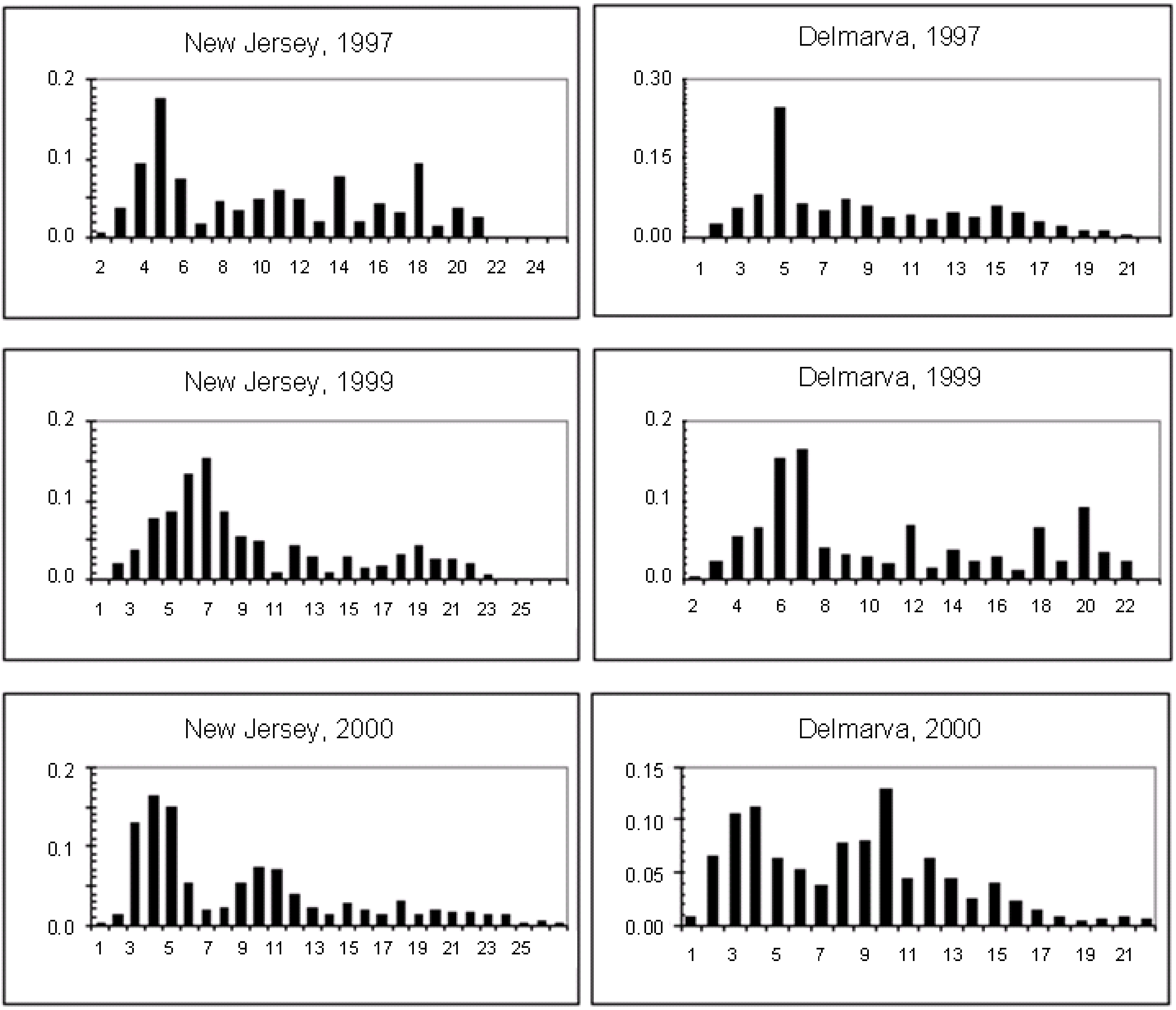

Figure 1. Age composition data (NEFSC 2003) for Atlantic surfclam in NEFSC clam surveys during 1997, 1999 and 2002 (*n* is the number of individual age determinations included).

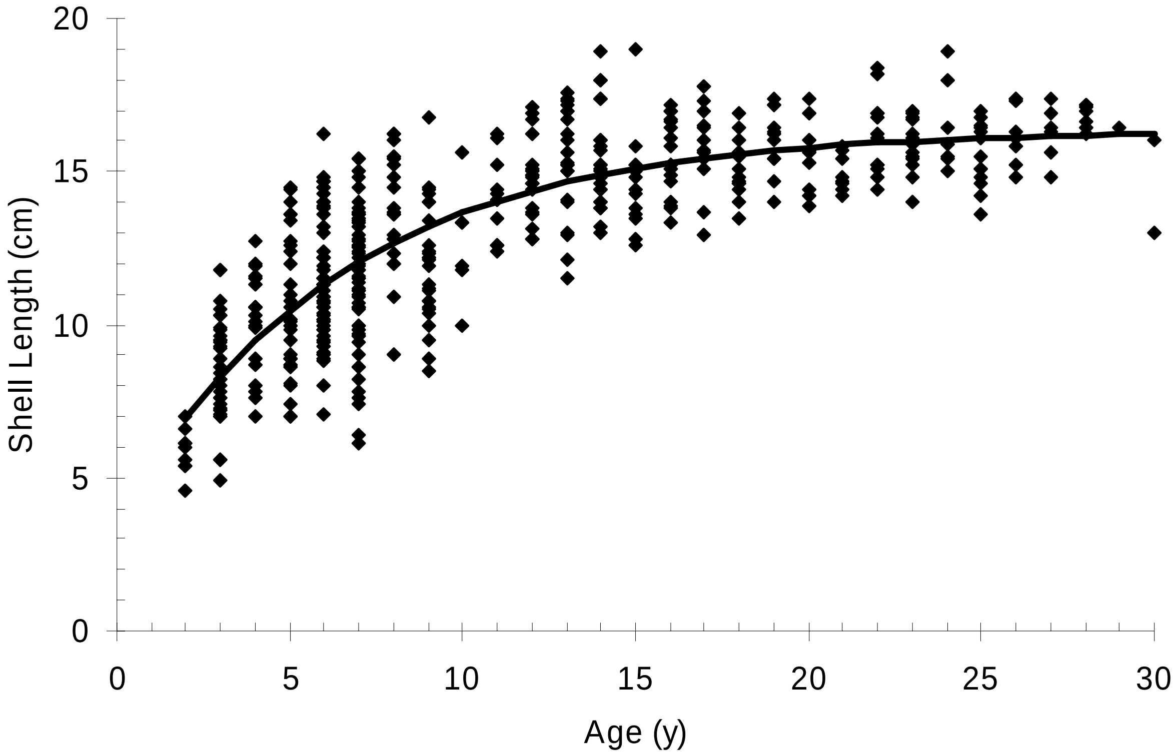

Figure 2. Atlantic surfclam shell length and age data collected during the 2005 NEFSC clam survey off New Jersey (survey strata 17, 21, 25 and 87-90, *n* = 517). The dark line shows the von Bertalanffy growth model fit to the data (K = 0.156 y^{-1}, t_0 = -1.54 y and L_{max}=16.3 cm, figure provided by L. Jacobson, NEFSC).

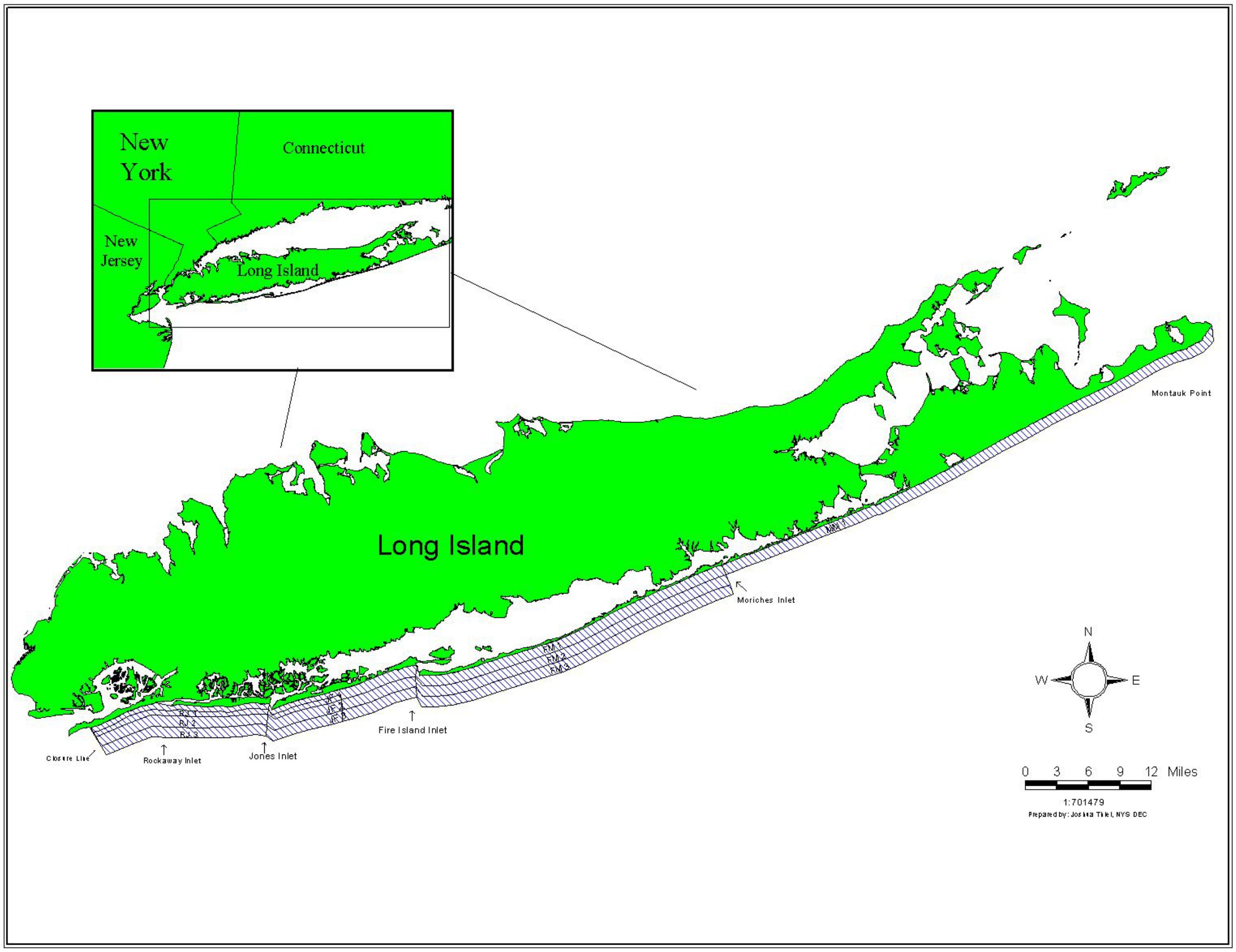

Figure 3. Areas sampled and survey strata used during the NYSDEC surfclam surveys (Davidson et al. 2005)

Figure 4. Pencil marks on the chondrophore of a surfclam shell. These marks are used to help position the shell and guide the saw in preparing NYSDEC age samples (photo provided by M. Davidson, NYSDEC).

Figure 5. A surfclam shell positioned on the saw used to section shells for age reading at NYSDEC (photo provided by M. Davidson, NYSDEC).

Figure 6. Annual marks in the chondrophore of a surfclam shell sectioned at NYSDEC (photo provided by M. Davidson, NYSDEC).

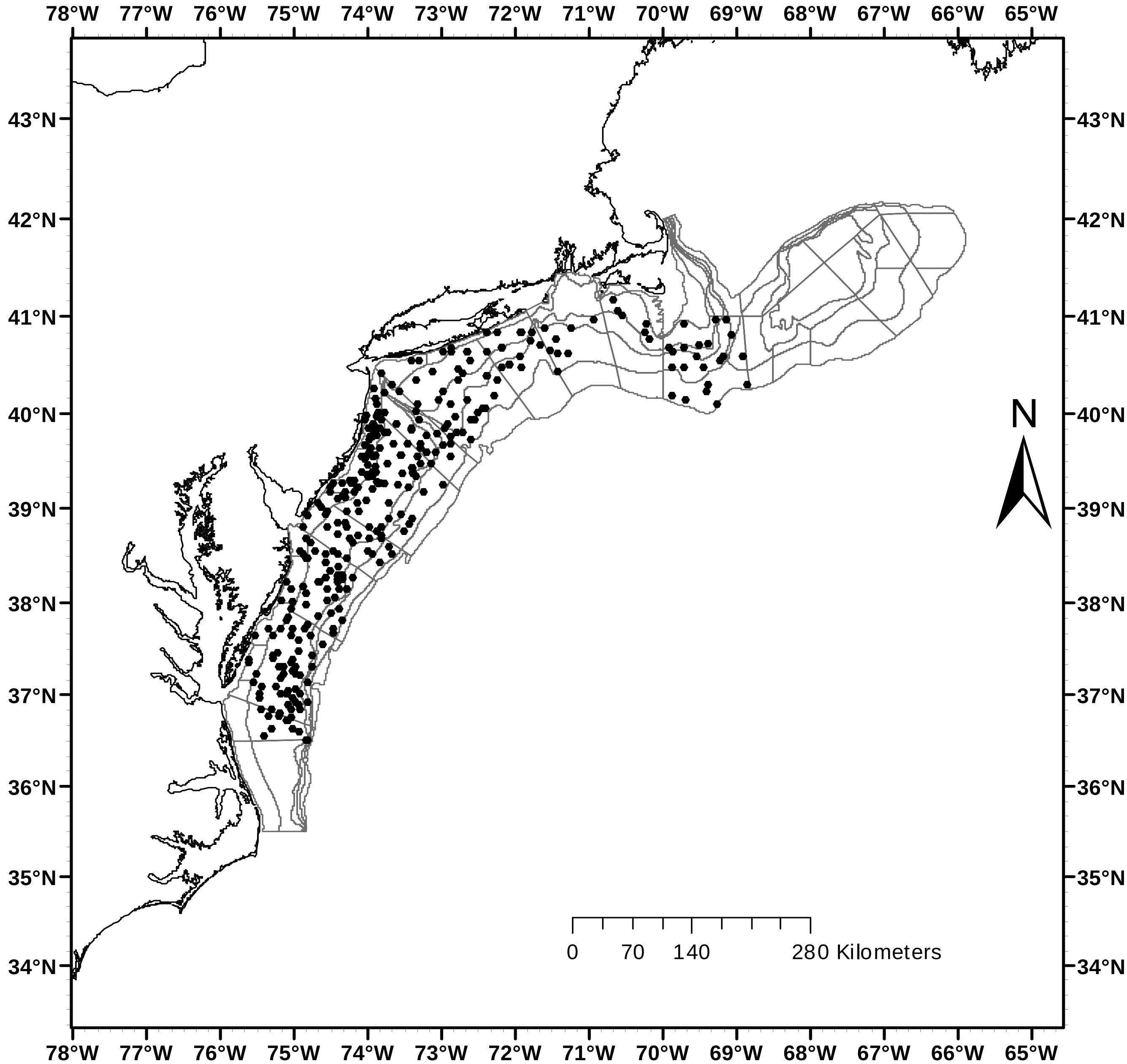

Figure 7. Shellfish survey strata and station locations in the 2002 NEFSC clam survey (figure provided L. Jacobson, NEFSC).

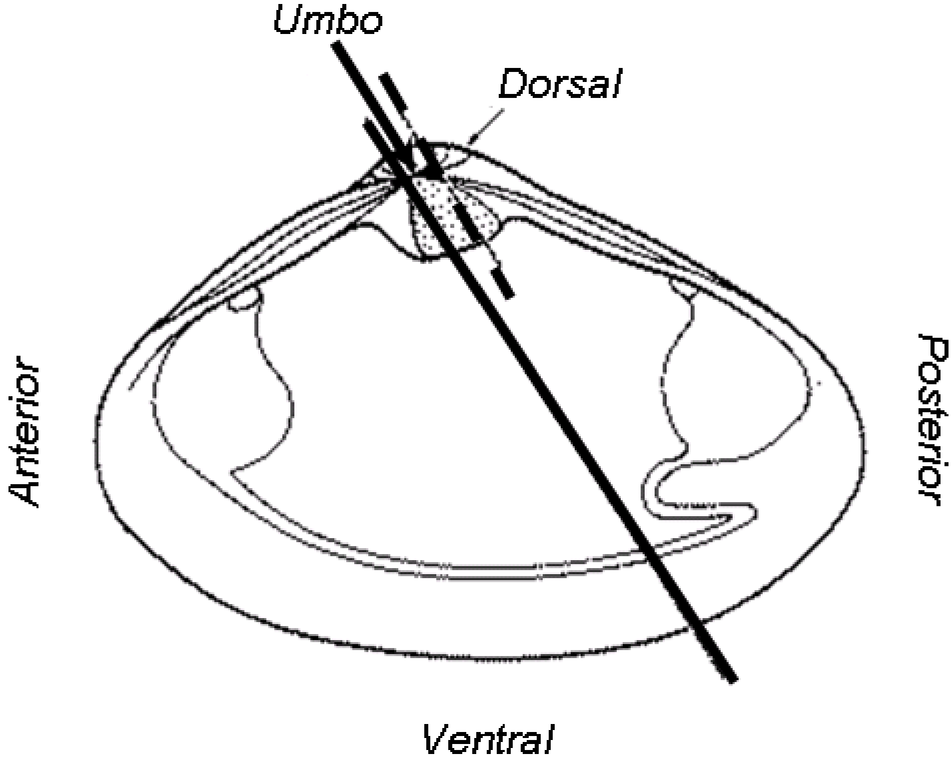

Figure 8. Location and direction of section through valve for sections used in aging Atlantic surfclam at the NEFSC (drawing from Ropes and Shepherd 1988).

Figure 9. A surfclam shell positioned against two diamond-impregnated blades used to cut chondrophore sections for aging Atlantic surfclam at the NEFSC (photograph provided by J. Burnett, NEFSC).

Figure 10. Photographic enlargements of thin sectioned chondrophores. The top image shows a section from a specimen that was 139 mm shell length and age 8. The lower image is for a specimen that was 137 mm shell length and age 13. The samples are thin sections viewed with transmitted light but annuli (hyaline zones) are dark bands because the image is photographic negative. (From Ropes and Shepherd 1988.)

APPENDIX 1. WORKSHOP AGENDA

Day One, Monday 7 November (1-5 pm)

I. Welcome (Frank Almeida)
II. Housekeeping (parking, access codes, computer/phone availability, etc.) (Jay Burnett)
III. Introduction of participants (All)
IV. Agenda/objectives (Jay Burnett)
V. Background (sampling, processing, aging, QA/QC)
    a. NEFSC at-sea sampling (John Galbraith)
    b. NY-DEC & SUNY-Stony Brook sampling/processing (Maureen Davidson)
    c. NEFSC processing, aging, QA/QC, & databases (Jay Burnett)
    d. Assessment overview/end uses of age data (Larry Jacobson)
       Reference collections (Jay Burnett)

VI. Summary/wrap-up/game plan for Day Two (Jay Burnett)

Day Two, Tuesday 8 November (8:30 am-5 pm)

I. Alternative aging method/meat weight study (Adriana Picariello)
II. Discussion:
    a. Errors in length measurements
    b. Seasonality of annulus formation (w/efforts to establish birthdate)
III. NEFSC processing demonstration (Blanche Jackson)
    a. Blanche also cut some NY samples w/ NEFSC method
IV. Joint aging session (All, led by Jay Burnett)
V. Hands-on processing, aging, etc. continued (Those interested)
VI. Informal aging exercise (All, led by Blanche)
VII. Summary/wrap-up/game plan for Day Three (Larry Jacobson, Jay Burnett)

Social (Dave Wallace)

Day Three, Wednesday 9 November (8:30 am-2 pm)

I. Results of aging exercise (Sandy Sutherland)
II. Plan post-Workshop exchange as basis for reference collection (All, led by Jay)
III. Discuss Workshop Report (All, led by Jay)
    Program descriptions
    Method description
    Processing/aging issues
    Develop consensus conclusions/recommendations
    Future plans

Adjourn

APPENDIX 2. Participants in the Atlantic Surfclam Aging Workshop held at the Northeast Fisheries Science Center in Woods Hole, MA during 7-9 November 2005.

Frank Almeida	NEFSC
Jay Burnett	NEFSC
Chase Cammarotta	NYSDEC
Maureen Davidson	NYSDEC
John Galbraith	NEFSC
Blanche Jackson	NEFSC
Larry Jacobson	NEFSC
Adriana Picariello	VIMS
Eric Powell	Haskin Shellfish Research Laboratory, Rutgers University
Sandy Sutherland	NEFSC (rapporteur)
Dave Wallace	Wallace & Associates
John Womack	Wallace & Associates

From left to right: E. Powell, J. Burnett, B. Jackson, S. Sutherland, A. Picariello, M. Davidson, C. Cammarotta, J. Womack, D. Wallace and L. Jacobson (November 9, 2005)

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